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Original Article

Relief Analysis of Dalma Range Jharkhand : A Case Study

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Abstract :
Dalma range occupies an south-western part of Chotanagpur highland between 25°45'N to 23°00'N and 86°00'E to 86°45'E. and its covers an area of about 2672.64km^2. This study region has various ranges such as Gurga-Baru, Urama, Chadari, Bhelxi, Khursi and Chekam. The relief various between 105m to 1,000m in this region. The present study includes detail analysis of absolute relief, relative relief, hypsometric analysis, dissection index, erosional surfaces etc. and their effects on the areal topography.
Keywords : *Absolute relief, relative relief, dissection index, hypsometric curve, altimetric frequency curve.*

Introduction:

The Dalma range occupies an south-western part of Chotanagpur highland between 25°45'N to 23°00'N and 86°00'E to 86°45'E. (Fig. 1) Dalma range relief varies between 105m to 1,000m and it covers an area of about 2672.64km^2. The main ranges of this region are Gurga-Baru hill (739m), Urama (415m) Chadari (440m), Bhelxi (780m), Khursi (590m) and Chekam (570m). The topography of the study area has diversified nature which provide a wide range for geomorphological study. Present study is devoted to the relief analysis of the Dalma Range, Jharkhand. Its includes the various relief features of the study area and their effects on the various landforms development in this region.

An initial step to study the geomorphological features of any area is the analysis of its relief features variations of the earth's surface or a part of it which become the focus of a geographic study of landforms. Relief and other geomorphic elements are also based on the differences in elevation. These geomorphic elements are absolute and relative relief, slope, dissection index, drainage density and frequency which help to classify the morpho-units of the terrain. However, in this paper, the elements which are directly related with the relief have been discussed. The present physical features of the study area have resulted in fragmental or remnantal shapes caused mainly by fluvial action of erosion. Some other denudational agencies have also affected the physical features of the Dalma range. The processes of evolution of the relative relief depend upon geological structure, type of rocks, climatic conditions and nature of the absolute relief of the area concerned. Differences in the types and structure of rocks and fluvial processes of denudation are definitely the most important factors in forming the present shape of relief in the study area.

The analysis and its morphology is based upon the three elements of landscape. structures that have been outline from Pre-Cambrian to the present time are due to enactment of various processes to produce landforms in different stages. Davis, W.M. (1954) stated that, "Hence all forms, however high and however resistance, must be laid low and thus, destructive process gains rank equal to that of structure in determining the shape of a landmass". Smith, G.H. (1935) states that "Relief is a concept intended to described the vertical extent of landscape feature without reference to absolute altitude or the slopes.

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"There is no generally accepted definition of relief but its most common measure is the range in altitude. Spark, B.W. (1961) relates that, "the nature and arrangement of the rocks are fundamental in the development of landforms. The structure of the rocks in the narrower modern sense of the world, affects the general pattern of relief while the lithology of individual beds influences the relief in detail. But there are areas where the relief does not seen to be affected by rocks, so that a geological map is not the only requirement for study of relief." The Dalma range occupies the southeastern part of Chhotanagpur highland. The present morphology of Dalma range is the product of the sculpturing of various denudational cycles. Former covers of the Pre-Cambrian mountains have not been removed but their roots have also been plained.

Absolute Relief:

The relief analysis consists the analysis of absolute relief, relative relief and dissection index. Absolute relief is the total elevation above sea level which is a function of constructive and destructive forces at work and forms a clue towards estimating the relative intensity of these forces. It is interpreted here with the help of contour map, altitudinal zones and area-height relations (Table-1).

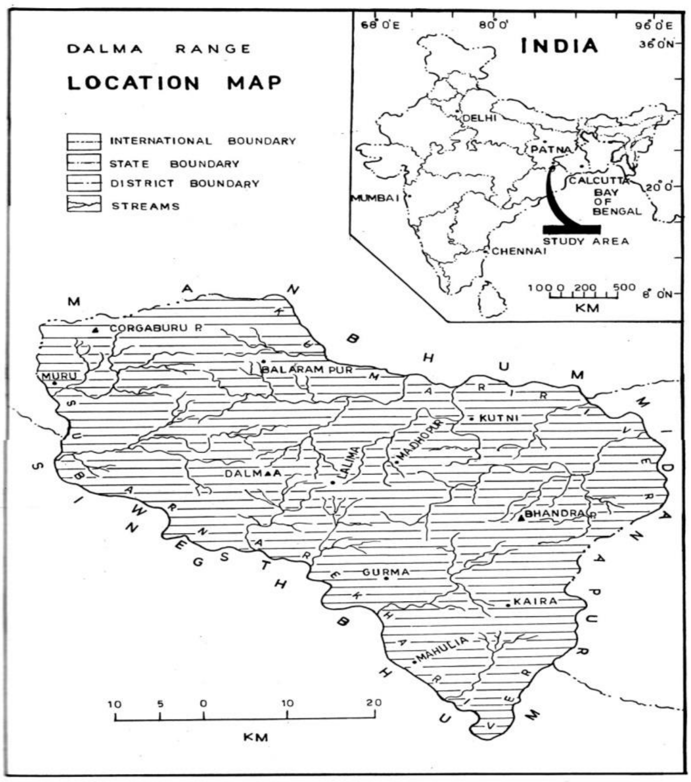

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Fig. 1

Altitudinal Zones:

The altitudinal zones have been obtained in order which is the base map of Dalma range. It has been gridded by 10.24km^2 per unit area. Each unit of the absolute height has been indicated by calculating maximum elevation with the help of contours, spot heights, triangulated heights, etc. Seven categories of absolute relief has been obtained and analysed for total of 261 units of the area. The total elevations of the area varies from a little below 150m in lower Subarnarekha valley in the southeast and over 900m in the upper part of the Dalma range in the northwestern part of the study area. General slope of the area is towards the northwest to southeast. The mean, median and modal values of the elevation are 318.0m, 274.8m and 246.1m respectively. Thus, it indicates the erosinal land surfaces in the mature stage of the landform development.

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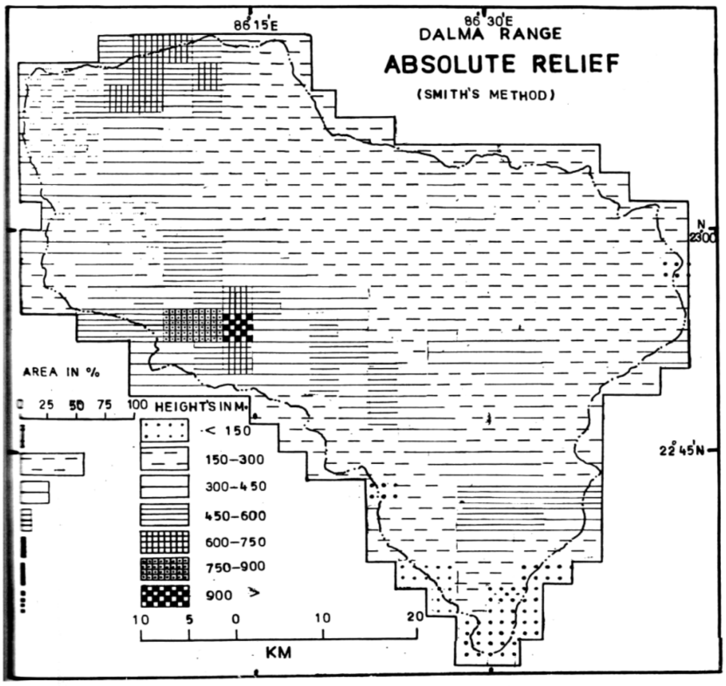

Fig. 2

Table-1 : Altitudinal Zones of Dalma Range by Frequency Distribution

Height Group (M)	Frequency	Area		
		(Km^2)	(%)	(Cum. %)
< 150	06	61.44	2.30	2.30
150 - 300	149	1525.76	57.15	59.45
300 - 450	69	706.56	26.43	85.88
450 - 600	26	266.24	9.95	95.83
600 - 750	08	81.82	3.06	98.89
750 - 900	02	20.48	0.76	99.65
900 >	01	10.24	0.35	100.00
Total	**261**	**2672.64**	**100.00**	

Mean: 318.0m; Median: 274.8m and Mode: 246.1m.

Fig. 2 shows the distribution of various altitudinal zone in the study area. It has been indicated that altitudinal zones having an elevation of less than 150m and comprises about 61.44km^2 or 2.30% of the study area. It includes the alluvial lower valley of Subarnarekha (105m) in the south-eastern part of the study area. A maximum area lies in the altitudinal zones of 150m-300m height group which covers about 1525km^2 or 57.15% of the total study area. This zone includes the Nangasoi (299m), middle Kumari (225m), lower Kumari (185m), Gurma (300m), Jam (299m), Kulandani (292m) valleys, Barbogala pahar (220m), Penchara (268m), Kumari (peneplains 262m, Sukiara gorge (290m), Kunobia escarpment (275m) and Dulukdih gorge (300m) in the northeast; upper Kumari (300m), Sobna (268m), Sona (300m), upper Subarnarekha (285m) valleys, Kadali (241m), Chakotia (275m), Raoacha (245m) pahars, Balram pur (291m), Birbhum (275m) peneplains, Rangagara gorge (215m) in the northwest; upper Kharaoti valley (300m), Mahulia (175m), Khengar (141m) peneplains, Ledasai pahar (275m) in the southeast and middle Subarnarekha valley (250m) in the southwestern part of the study area.

A second maximum altitudinal zones of 300m-450m covers an area of about 706.56km^2 or 26.43% of the study area. It is represented by the Sanka valley (425m), Urma (415m), Chadri (440m), Amda (409m), Lailam (336m) pahars, Bara Banki gorge (449m), Chandil hill-complex (325m), Pardih scarp (350m) in the northwest; Lankaicuni pahar (440m), Kesarpur gorge (386m) in the southeast and Gurma hill-complex (449m) in the southwestern part of the

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study area. The third maximum altitudinal zones of 450m-600m comprises an area of about 266.24km^2 or 9.95% of the study area. This category is represented by Dimna Jhar gorge (590m) in the northwest; Khursi (590m), Chekam (570m) pahars, middle Kharaoti valley (499m) in the southeast and Sapghara valley (575m) in the southwestern part of the study area. The height of 600m-750m occupies an area of about 81.82km^2 or 3.06% of the study area. This category is only represented by Gorga-Buru hill-complex (739m) in the northwestern part of the study area. The altitudinal zone of 750m-900m occupies an area of about 20.48km^2 or 0.76% of the study area. This category is represented by Bhelxi Pahar (780m) in the northwestern part of the study area.

The highest altitudinal zone, i.e., over 900m, occupies an area of about 10.24km^2 or 0.35% of the study area. This category is represented by Dalma hill (1000m) in the northwestern part of the study area.

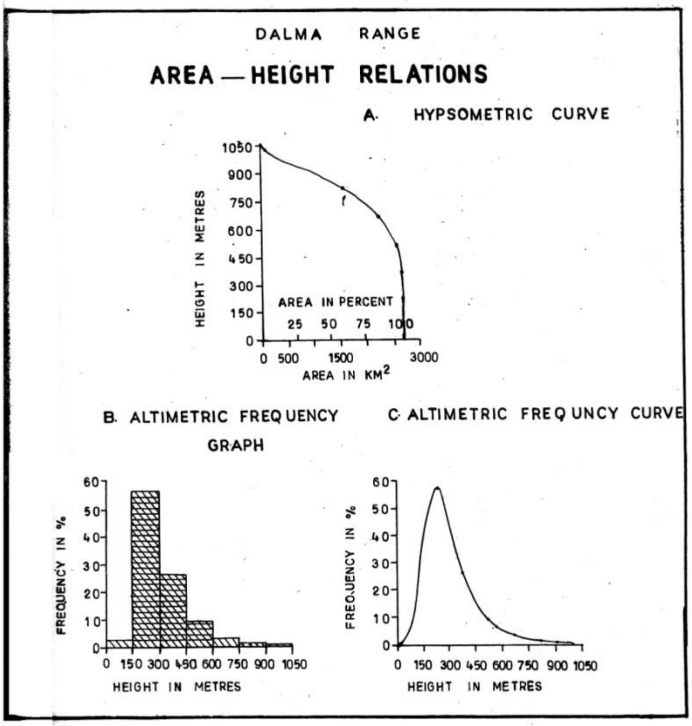

Fig. 3

Area-Height Analysis:

Area-height relation shows the relative extent of highlands and lowlands in each altitudinal zone. Baulig, H. (1933) recognises that the area-height analysis has successfully employed of erosional landforms. It measures the construction of area-height curve, hypsographic curve and altimetric frequency diagrams (Fig. 3).

Hypsometric Curve:

Fig. 3 indicates the hypsographic curve of Dalma range. It represents a maximum of 1525.76km^2 or 57.15% of the study area lies in the height category of 150m- 300m. The next maximum area helds the height group of 300m-450m. It is noticed that elevation of over 900m and less than 150m occupy small area only. The former category shows the ridges over the higher upland and the crests of hillocks and valley bottoms. The hypsographic curve represents the present uplifted peneplains in the height range of 600m-750m. Infact, the occurrence of two extensive peneplained surfaces, at the height between 150m-200m in the northeast and the other at about 250m-300m in the northwest which is confirmed by the serial profiles of the area (Fig. 3). The curve represents different breaks in slope at elevation of 450m and 900m.

Altimeric Frequency Diagrams:

The data for altimetric frequency analysis has been obtained by noting the highest elevation within each square grid and tabulating their frequency at a height interval of 150m (Table 3). Low category, i.e., less than 150m, covers most of the alluvial plains of the lower part of the Subarnarekha and lower tributaries of Sobna, Sanka, Sona, Gurma, Kumari, Kharaoti rivers.

The altimetric frequency graph shows an uneven distributional pattern of area within each category. The graph denotes that maximum frequencies are lying between 150m-300m which confirms the presence of planation surfaces at the elevations of 150m-200m and 250m-300m in the eastern and western parts of the study area respectively. It is generally consisting the lower Dalma range surface in the central and avoid of the western and southern parts. 26.43% of the study area lies in the height group of 300m-450m. The breaks of slope at 600m and 750m are also observed.

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These have been recognised earlier stage in area above 900m. The higher planation surface at 600m-650m, covers a small area.

Relative Relief:

A scientific and systematic study of relative relief was done by Smith, G.H. (1935). There has been frequent applications of relative relief concept since the time of Smith, G.H. and its effect over the general landform patterns has also been recognised for which the landform regions have proved much meaningful. 'Relief Energy' method, based on the difference of highest and lowest altitude in area has been used as early as 1911 by Partsch, J.S. and later adopted by Krebs, N. (1972), Schrepfer, H. and H. Kallenr (1930), Weaver, G.D. (1965) other but with connotations as relative altitude of relative relief. It presents a better index of erosion along with the stage. But for being more precise and explicit, it need to be correlated with the absolute relief or altitude. The correlation coefficient between two variables, in general, shows an increasing trend with the time when the erosion initiated.

Relative relief in general denotes the actual variaion of height in am unit area with respect to its local base level. 'Drainage relief', 'topographic relief' and 'relative relief' are expressed variously 'local relief'. These are different study among the highest and lowest altitudes in a limited area. Later Dov Nir (1957) suggested that the ratio between relative and absolute relief can be considered as a measure of the 'dynamic potential' of the area.

Table-2 : Areal Distribution of Relative Relief Categories over Dalma Range

Relative Relief (m)	Symbol	Frequency	Area		
			(Km^2)	(%)	(Cum. %)
< 15	Rel	36	368.64	13.82	13.82
15 – 30	Rl	46	471.04	17.62	31.44
30 – 60	Rml	26	266.24	9.96	41.34
60 – 120	Rm	51	522.24	19.50	60.84
120 – 240	Rmh	56	573.44	21.45	82.29
240 – 480	Rh	40	409.60	15.33	97.62
480 >	Rh	06	61.44	2.38	100.00
Total		**261**	**2672.64**	**100.00**	

Choropleth maps (Fig. 5) outline the relative relief of different categories by straight boundary lines where as the isopleth map (Fig. 3) shows the trend of different categories of relative relief. The present study analysed that area has been selected with a square grid having an unit area of 10.24 km^2 and then, the difference in elevaion between the highest and lowest points for each square unit has been calculated (Fig 4). The isopleth map depicts the irregularities of the upland terrain which varies from below 15m along the lower Subarnarekha valley in the southeast and above 480m along Chekam pahar (570m) in the southwestern part of the study area. It is, however, noted that the greater part of the upland surface has a relative relief ranging from 30m-60m. Further, it has been divided into three broad categories of low, moderate and high relative relief and six sub-categories as suggested by Singh, R.L. (1967). This is represented by a choropleth map.

The mean, median and model values of relative relief in the area has been 126.37m, 64.28m and 34.38m respectively. These values, pertaining to low and moderoote relative relief indicate that the terrain in general is highly dissected surface. Occurrence of peneplained surface with dome-shaped hills and ridges projecting over them inspite of recent upliftment suggest the former senile stage of the landscape in the area.

Areal Distribution of Relative Relief Categories and their Correlation with Absolute Relief

Table-2 shows that moderate degree of positive correlation is obtained between the relative relief and absolute relief in the area. The Karl Pearson's coefficient of correlation is + 0.44 only. The distribution of relative relief and their correlation with absolute relief are given below:

Extremely Low Relative Relief (Rel: 0-15m)

The area under extremely low relative relief (less than 15m) occurs in patches accounting for 368.64km^2 or 13.82% of the study area. Table-3 shows that 5.5% to 94.5% area of the study region falls under extremely low relative relief in the height category of less than 150m and 150m-300m respectively. Area under extremely low relative relief less than 15m occurs in Rangagara gorge (215m) and Birbhum Peneplains (291m) in the northwestern part of the study area. (Fig. 5 & 6)

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Low Relative Relief (Rl: 15m-30m)

Area of low relative relief (15m-30m) covers about 471.04km^2 (17.62%) of the study area. It is the third largest category interms of areal Average. It is mostly characterize by alluvial flood plains along the rivers and flat-topped surface on the uplands.

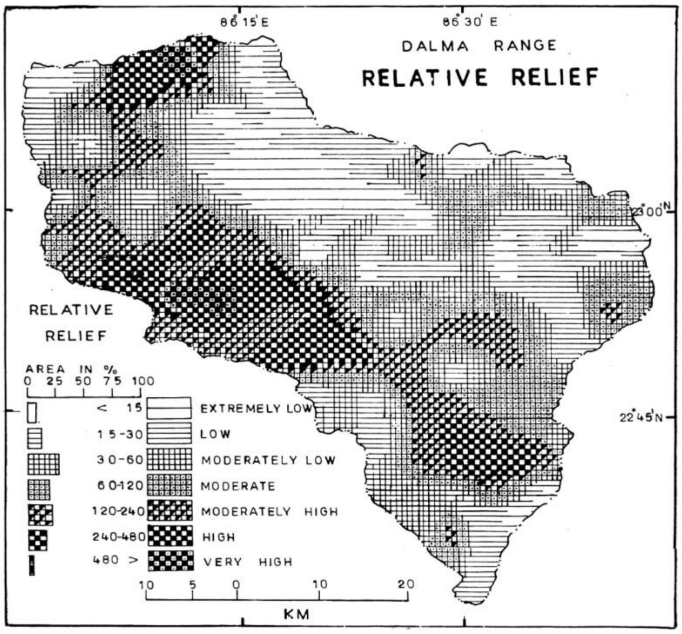

Table-3 : Correlation between Relative Relief and Absolute Relief over Dalma Range

Absolute Relief (m)	Relative Relief Categories (m)														Total	
	Rel (< 15)		Rl (15-30)		Rml (30-60)		Rm (60-120)		Rmh (120-240)		Rh (240-480)		Rvh (480 >)			
	F	%	F	%	F	%	F	%	F	%	F	%	F	%	F	%
< 150	02	5.5	03	6.5	01	3.9	-	-	-	-	-	-	-	-	06	2.30
150–300	34	94.4	42	91.3	25	96.1	37	72.5	10	17.9	01	2.5	-	-	149	57.15
300–450	-	-	01	2.1	-	-	14	27.5	44	78.6	10	25.0	-	-	69	26.43
450–600	-	-	-	-	-	-	-	-	02	3.5	24	60.0	-	-	26	9.95
600–750	-	-	-	-	-	-	-	-	-	-	05	12.5	03	50.0	08	3.06
750–900	-	-	-	-	-	-	-	-	-	-	-	-	02	33.3	02	0.76
900 >	-	-	-	-	-	-	-	-	-	-	-	-	01	16.7	01	0.35
Total	36	100.0	46	100.0	26	100.0	51	100.0	56	100.0	40	100.0	06	100.0	261	100.00
%	13.82		17.62		9.90		19.50		21.45		15.33		2.38		100.00	

This is also evident from Table-3 which shows that 6.6%, 94.4% and 2.1% of the areas are under low relative relief with height category of less than 150m, 150m-300m and 300m-450m respectively. The narrow alluvial flood

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plains along the Subernarekha valley and their tributaries account for larger part of this category. Low relative relief category is also found on the undulating nature of middle Kumari (225m), Jam (299m), Nangasai (299m) valleys, Dulukdih gorge (300m) in the northeast; upper Kumari (300m), upper Subarnarekha (285m), lower Kharaoti (125m) valleys, Raocha pahar (245m) in the northwestern part of the study area. A subdued topography with gentle valley slopes and low dissection, characterizes the drainage basin of lower Kumari and its tributaries in the northeastern part of the study area.

Moderately Low Relative Relief (Rml: 30m-60m)

Moderately low relative relief (30m-60m) occupies an area of about 24.24km^2 or 9.90% of the study area. It is represented by the granite-gneiss terrain of the Dalma range that descends to lower elevations along a fault line scarp. This is also evident from Table 3 that 3.9% and 96.1% of the area under moderately low relative relief lie in the height categories of less than 150m and between 150m-300m respectively.

The moderately low relative relief is also found in Barbogala pahar (220m), Kunokia escarpment (275m), Sukiara gorge (290m), Kumari peneplain (262m) and Gurma valley (300m) in the northeast; Sona (300m), Sanka (425m) valleys, Chakotia (275m), Lailam (2336m), Kadali (241m) pahars in the northeast and Khengar peneplain (141m), Ledasai (275m) pahar, lower Subarnarekha valley (105m) in the southeastern part of the study area.

Moderate Relative Relief (Rm: 60m-120m)

The area under moderate relative relief (60m-120m) is covers about 522.24km^2 or 19.50% of the study area. This category has the second largest areal coverage of the upland surface, generally obtaining an intermediate location between the flat-topped upper upland surface and the lower eroded undulating terrains. It is also observed along the deep dissected flanks to the upland where the rivers are deeply incised. Thus, it shows greater altitudinal variation than the other relief categories. This is also evident from Table 3 which shows that 72.5% and 27% area under moderate relative relief lie in the height categories of 150m-300m and 300m-450m respectively.

The area under moderate relative relief is associated with lower Kumari (185m), Kulandani valleys (292m), Penchara peneplain (282m) in the northeast; Sobna valley (263m), Bara Banki gorge (449m) in the northwest and Lankaiaini pahar (440m), upper Kharaoti valley (300m) in the southeastern part of the study area.

Moderately High Relative Relief (Rmh: 120m-240m)

Moderately high relative relief (120m-240m) accounts for 573.44km^2 or 21.45% of the study area. This category has the largest coverage of the upland surface. It mostly occupies the upper margins of residual hills and highly dissected parts of the study area. Table 3 shows that 17.9%, 78.6% and 13.5% area under moderately high relative relief lie in the absolute relief category of 150m-300m, 300m-450m and 450m-600m respectively.

Steep scarp along the northwest and southeastern margins of the rejuvenated lower Dalma range indicate the general pattern of uplift in the area. These scarps are indicated by the closer spacing of isopleths on the relative relief map (Fig.3). It is associated with the Chadri pahar (440m), Chandil hill-complex (325m), Dimna Jhar gorge (590m) in the northwest; Kesarpur gorge (386m), Khursi pahar (590m), Muhulia peneplain (175m) in the southeast and middle Subarnarekha valley (250m) in the southwestern port of the study area.

High Relative Relief (Rh: 240m-480m)

High relative relief (240m-480m) covers an area of about 409.60km^2 or 15.33% of the study area. This category has the fourth largest areal coverage of the study area. Table 3 shows that about 60.0% of this category is associated with the undulating terrains of the stream divides of 450m-600m, 2.5% covers the less dissected parts of the border interfluves (150m-300m), 25.0% covers in the altitudinal range of 300m-450m and the flat-topped surface of dissected range. Only 12.5% is confined to higher altitudes of 600m-750m. This category is observed along the dissected parts of the Gurga Buru hill-complex (739m), Pardih scarp (350m), Bhelxi (780m), Urma (415m) pahars in the northwest; Chekam pahar (570m), middle Kharaoti valley (499m) in the southeast and Gurma hill-complex (449m), Sapghara valley (595m) in the southwestern part of the study area.

Very High Relative Relief (Rvh: Over 480m)

This category (over 480m) covers an area of about 61.44km^2 or 2.38% of the study area. This is also evident form Table 3 which shows that 50.0%, 33.3% and 16.7% area under very high relative relief lie in the height categories of 600m-750m, 750m-900m and over 900m respectively. It is mostly confined to the upper most slopes of the Dalma hill (1000m) in the north-western part of the study area.

Dissection Index:

Dissection index is the ratio between relative relief and absolute relief. The dissection index per square kilometer varies from 0.00 to over 0.40. Five categories of the dissection index have been plotted after calculation to draw choropleth map (Fig 6) and to interpolate isopleths (Fig. 5). Each category finds expression in the configuration of the land. The isopleth map shows the trend of dissection index per square kilometer. A superimposition of dissection index maps over relative relief maps reveals the following:

- Areas of high relative relief have higher index of dissection,
- Areas of intermediate relative relief have moderate to high index of dissection,

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- Areas of low relative relief have a low index of dissection.

Scarps, highlands and areas of high gradient have not organized bunches of drainage lines, but their incision is also well marked to show a high index of dissection. Dov Nir (1957) states, "As a perfect criterion of relief expression, the concept of relative altitude is not entirely satisfactory. Equal relative altitude are not always of equal importance since their absolute altitudes may differ. The picture gained from relative altitudes only is static as it fails to take into account the vertical distance from the erosinal base that is the dynamic potential of the area studied". Dov Nir called these values, as "indices of the degree to which dissection has advanced," which simply varies between O (complete absence of dissection) and 1.0 (vertical cliff at sea level).

Table-4 : Areal Distribution of Dissection Index Values in Dalma Range

Dissection Index	Symbol	Frequency	Area		
			(Km^2)	(%)	(Cum. %)
< 0.1	Dl	23	235.50	8.81	8.81
0.1 - 0.2	Dm	55	563.22	21.07	29.88
0.2 - 0.3	Dmh	40	409.60	15.33	45.21
0.3 - 0.4	Dh	38	389.12	14.56	59.77
0.4 >	Dvh	105	1075.20	40.23	100.00
Total		**261**	**2672.64**	**100.00**	

Mean: 0.20; Median: 0.33 and Mode: 0.43

To obtain the dissection index, the area under-study has been covered with a network of squares having a unit area of 10.24km^2 and the ratio between relative relief and absolute relief has been calculated for each grid. The data has been divided into three broad categories, namely low (0.0-0.1), moderate (0.1-0.3) and high (over 0.3) and five sub-categories as suggested by Singh, R.L. (1967).

Table 4 denotes that dissection has not progressed to any great extent because the area is still largely characterized by flat or gently undulating upland surfaces. Steep declivities occur only on the Dalma range margins and along flanks of residual hills and ridges. The mean, median and model values of dissection index have been found to be 0.20, 0.33 and 0.43 respectively. It is noted that the modal value of dissection index is more as compared to its mean and median values. Infact the modal value of 0.43, indicated that the present topography is in the 'early mature stage' of landforms. The lower mean and median values of 0.20 and 0.33 respectively are, however, typical of the 'late mature stage'. Thus, the area is experiencing accelerated erosion after its upliftment in the Late Tertiary times.

Areal Distribution of Dissection Index Categories and their Correlation with Absolute Relief

Table-4 shows that a moderate degree of positive correlation between dissection index and absolute relief (+0.65). It is also noted that the dissection index regions more or less coincide with the various altitudinal zones. This is clear from the following description of these three broad categories and five subcategories of dissection indices.

Low Dissection Index (Dl:0.0-0.1)

This category covers 235.50km^2 (8,81%) of the study area. It is the fifth largest category interms of areal coverage. It generally occupies areas of lesser elevation (including alluvial flats) along the flat-tops on the uplands in the northwest and alluvials plains in the southeastern parts of the study area. Table 4 shows that the height categories of 150m-300m account for total area under low dissection index respectively. It is found in lower Kumari valley (185m) in the northeast and upper Kumari valley (300m), Rangagara gorge (215m) and Birbhun peneplain (275m) in the north-western part of the study area.

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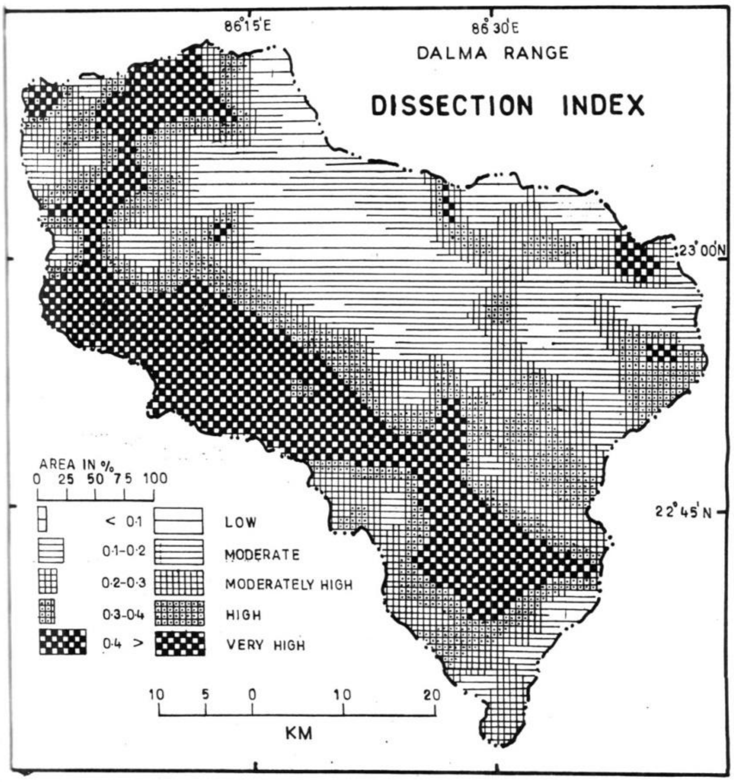

Fig. 5

Moderate Dissection Index (Dm: 0.1-0.2)

Moderate dissection index characterizes of about 563.22 km^2 or 21.07% of the study area. It is the second largest category interms of areal coverage. It is associated mostly with areas of the low elevations (l50m-300m) covering large parts of the dissected upland. Nonetheless, it shows same diversity with respect to its altitudinal distribution. In this area, the rivers flow in differently over hard crystalline Archaean rocks, namely the granites and gneisses including charnokites. However, the harder Dharwarian rocks (particularly quartzites, sandstone and conglomerates) stand above the undulating upland surface. Table-4 shows that 3.6% of this category is associated with riverine plains (less then 150m) and 96.4% with dissected valley tracts (150m-300m) respectively.

Moderate dissection index covers large areas, including middle Lumari (225m), Nangasai (299m) valleys, Barbogala pahar (220m), Sukiara (290m), Dulukdih (300m) gorges, Kumari peneplain (262m) in the northeast and Balrampur (291m) peneplain, Sona valley (300m) and Chakotia pahar 4275m) in the northwestern part of the study area. Deep incision by streams, at several places, indicates that area is maturely dissected.

Moderately High Dissection Index (Dmh: 0.2-0.3)

Moderately high dissection index (0.2-0.3) characterizes of about 409.60km^2 or 15.33% of the study area. It is the third largest category interms of areal coverage. It is generally associated with the deeply dissected flanks of residual hills where the rivers are deeply incised and the resistant rocks have been helpful in attaining a moderately high dissection. Table-5 reveals that 7.5%, 72.5%, 17.5% and 2.5% of the area under moderately high dissection index lie in the altitudinal zones of less than 150m, 150m-300m. 300m-450m and 450m-600m respectively.

Moderately high dissection index covers large areas including Penchara peneplain (268m), Kunokia escarpment (275m), Jam valley (299m) in the northeast, Kadali (241m), Urma (415m), Raoacha (245m), Lailam (336m) pahars in the northwest and upper Kharaoti (300m), Gurma (300m), lower Kharaoti (125m), lower Subarnarekha (105m) valleys, Kesarpur gorge (386m) in the southeastern part of the study area. The uplands of this area are composed of Upper Carboniferous and Lower Triassic sandstones that account for moderately high dissection index.

High Dissection Index (Dh: 0.3-0.4)

About 389.12km^2 or 14.56% of the study area falls under this category. It coincides with the highly dissected hill tops and the steeply sloping margins of the Dalma range. It is the fourth largest category interms of areal coverage. Table-5 shows that the altitudinal zone of less than 150m, 150m-300m and 300m-450m account for 2.6%, 52.6% and 44.8% of the study area under high dissection index respectively.

The largest patch of high dissection index coincides with the highlands of Kulandani valley (292m) in the northeast; Sobna (263m), Sanka (425m) valleys, Bara Banki gorge (449m) and Chadari pahar (440m) in the northwest and Lankaiaini pahar (440m), middle Kharaoti valley (499m) and Khengar peneplain (141m) in the southeastern part of the study area.

Very High Dissection Index (Dvh: Over 0.4)

The area under very high dissection index (over 0.4) occurs in Patches, accounting about 40.23% (nearly 1075.20km^2) of the study area. This category has the largest areal coverage of the upland surface. Table-5 shows that the altitudinal zones of 150m-300m, 300m-450m, 450m-600m, 600m-750m, 750m-900m and over 900m account for 22.9%, 42.5%, 23.8%, 7.6%. and 0.9% of the high dissection index respectively. It is often associated with resistant rocks of granites and gneisses.

This category includes the upper Subarnarekha valley (285m), Jham gorge (590m), Gorga Buru (739m), Chandil (325m) hill-complex, Pardih scarp (250m), Dimna Jhar gorge (590m), Dalma (1000m), Bhelxi (780m) pahars in the northwest; Khursi (590m), Ledasai (275m), Chekam (570m) pahars, Mahulia peneplain (175m) in the southeast and middle Subarnarekha (250m), Japghara (575m) valleys and Gurma hill-complex (449m) in the southwestern part of the study area.

Erosional Surfaces:

Altitudinal zone map (Fig. 3) and contour map (Fig. 1) are helpful in the quantitative study of the landform and fail to depict the individual geomorphic forms and landscape assemblages. Therefore, serial profiles are essential to explain the relationship of slopes, correlation of terraces and topography with lithology and structure. From this purpose nearly ten profile lines are drawn, five running from east-west and five profiles in the north-south direction (Fig. 3). Surface history is essential to arrange the surface expressions of the past and present in relation to its structural framework and landscape cycles. Singh, R.P. (1958) states that, "the story of landscape evolution in Chhotanagpur may be said to consist of several chapters involving erosion and deposition and folding, faulting, warping and tilting. Volcanic outburst has interrupted its history while the imprint of some has been obliterated by the closeness mark of time."

Davis, W.M. (1954) said, "However rare it may be to find peneplains still holding today the altitude with respect to base level that they must have held while they were slowly worn down, the facts of observation on partly dissected through the stages of short youth and longer maturity for into very old ages. The surface history can only be appreciated if stages of structural growth are kept in view in relation to drainage. Every chronology must have its bearing upon its anatomy in relation to denudation cycles." An erosion surface is generally a product of sub-aerial denudation. It is distinct from both structural as well as from constructional surfaces and sometimes, may include even tops of hills, mountain slopes and sea cliffs. But usually, it is a level or gently sloping surface of faint relief which is the end product of either complete of incomplete cycles of erosion. Though, the Dalma range has been an ancient landmass, it has experienced several phases of deposition, orogenic, subsidence and deposition in linear depressions during Gondwana times and successive upliftments of some its parts during the End-Tertiary and Pleistocene time has greatly affected its topography.

The different structural patterns that form the essential basis for the genetic classification of landforms are the following:

- Archaean mountain system consisting of corrugated strata of complex character,
- Dhanjori sandstone-conglomerate lying; unconformably over the denuded Archaean base,
- Dalma and Dhanjori lava flows spreading over the denuded synclines of the Archaean mountains and the Dhanjori conglomerate beds,
- Granite rocks injected with dykes forming rectangular ridges,
- Laterite capped plateaux with flat tops,
- Tertiary gravels lying over the eroded Archaean base, and Recent alluvium lying over the Archaean base.

The upland provides evidences of polycycle topography. The sequence of events resulting in the formation of the present landscape. Evidences derived from the studies of its structure, relief and drainage along with profiles, field sketches and field investigations help in constructing its story.The Archaean uplift resulted in folded structures stills to be seen in their denuded state on the northern and southern margins and in small bits with in the whole area. The Archaean fold mountains were probably peneplained during the early sub-aerial erosion cycle. The Archaean rivers feed with numerous streams must have drained the entire upland region. This landscape may be termed the Pre-Dalma landscape for extensive lava flows over the denuded surface, interrupted the Pre-Dalma erosion cycle. New streams must have be initiated from Dalma range lava regions to feed the surviving streams.

The study of the landscape bears the marks of the following events from the Cambrian to the Tertiary:

- A long period of erosion eventing out the irregularities of a gneissic and granitic Pre-Cambrian surface,
- An ice age in the Upper-Carboniferous,

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- Major trough faulting in Permian times,
- Uplift in the Semi-arid conditions of the Triassic days when some three hundred fifty metres of unprotected lower Gondwana sediments were stripped away and the massive sandstone of the Mahadeva series were formed,
- Folding of Dharwar rocks during Huronian orogeny and their subsequent peneplanation resulting in the formation of the Pre-Dalma landscape.
- A valcanic outburst in the Triassic,
- Rajmahal lava flow on the northeastern upland, and Dalma lava flow on the western upland.

The Permian-Triassic cycle was interrupted by a volcanic outburst in the Jurassic and Early Cretaceous. Pre-Tertiary landscape, peneplained more than once in previous erosion cycle, may be pictured as a low undulating plain of wide extent sloping gradually to the east to end in the Pre-Tertiary sea. The story of the Tertiary is described the elevation seems to have taken place mainly in the Early Miocene period to the extent of at least 300m in western Dalma range, i.e., subsequent to the out pouring of the Deccan trap. Small upland, south of Manbhum in East Singhbhum and the elevated Late Tertiary gravels in eastern Singhbhum mark the final stage of Tertiary uplift. Initial of later cycles of erosion in the area with the upliftment of the western Chhotanagpur, including the area of upper Dalma range, by about 300m in Mid-Miocene and whole of Chhotanagpur by another 200m in Pliocene-Pleistocene times.

The above-mentioned sequence of events and analysis of various types of profiles reveal the existence of the following erosion surfaces in the study erea (Fig. 6 & 7):

900m-1000m High Surface of Residual Hill-Tops on Upper Dalma Range

a) The Upper Dalma Range Surface (600m)
b) The Lower Dalma Range Surface (300m-350m)
c) The Lower Kumari Surface (150m-200m)
d) The Lower Subarnarekha Surface (100m-125m)

High Surface of Residual Hill-Tops on Upper Dalma Range 900m-1000m

Several residual hills of 900m-1000m high projected above the gneissic surface of the Dalma range are observed. These hills in general, have flat-tops with steep marginal slopes. The Dalma pahar (1000m). Bhelxi pahar (780m), provide such an example and it is composed of resistant Mahadeva sandstone and conglomerates. Similarly the Dimana Jhar Gorge (590m) lies in the northwestern part of the study area.

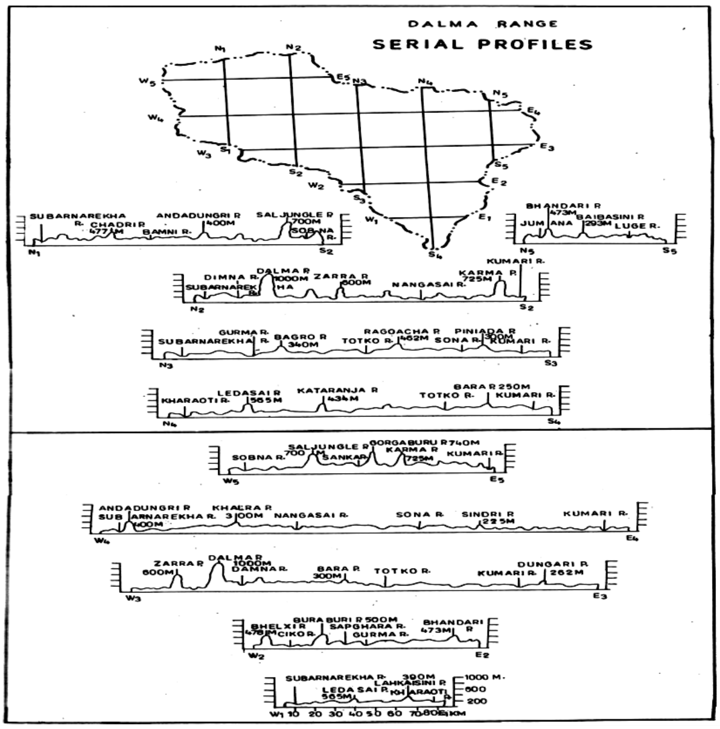

Fig. 6

The Upper Dalma Range Surface (600m)

The upper Dalma range surface has an average elevation of 600m. Its elevation is attributed to the Mid and End-Tertiary uplifts. Consequently, its northern, southeastern and southwestern margins are highly dissected by steams which have their sources in these parts. The descent of the upland surface towards the Subarnarekha and Kumari basins is characterized by deep scarps.

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Faint relief with gentle undulations and occasional hills characterize most of this upland surface. Streams with broad and shallow valley flow in differently over rocks of varying resistance of the upland surface but they descend the margins forming water-falls and entrenched meanders. Several residual hills rise above this upland surface, like the Gurma hill complex (449m), Chekam (570m), Ledasi (275m), Khursi (590m) pahars in the neighborhood of Sirkabad. A few of these are exfoliation domes. The monotony of gentle undulation of the upland surface locally known as 'dome' is relieved only when a dome or hummocky boulder or 'Tor' dots the landscape. However, the actual configuration of these hill features is determined by the presence of more than one divisional plane in the granites and gneisses.

The Lower Dalma Range Surface (300m-350m)

The lower Dalma range surface with an elevation of 300m-350m lies immediately to the north and east of the upper Dalma range surface. It is composed of Archaean granites, gneisses and Dharwar rocks. This surface has been partly breached due to headword erosion by the tributary streams of the Subarnareha and Kumari rivers.

In contrast to the lower Dalma range surface, it is deeply dissected. River courses on its other margins are marked by water-falls and gorges. For example, the Nangasai river has curved out along narrow gorge, 10.0km in the below its confluence with the Gontbera. A 30.0m high water-fall lies at head of this gorge. Generally having an elevation of about 350m occurs in the northwest and southeastern parts of this surface.

The Lower Kumari Surface (150m-200m)

The narrow strip of this category between Barbogala pahar (220m) and Kesurpur gorge (386m) through which the Sona river meanders forms the lower Kumari surface. It has an average evevation of about 150m-200m. This surface extends from Nanagasai in the north and Gurma hill-complex in the west. The formation of this surface is attributed to the Pliocene-Pleistocene uplift which also elevated the lower Dalma range. This surface is now being breached by headward recession of Dimana Jhar fall over the lower Kumari, 10.0km down stream from Mahulia and formation of entrenched meanders further down stream.

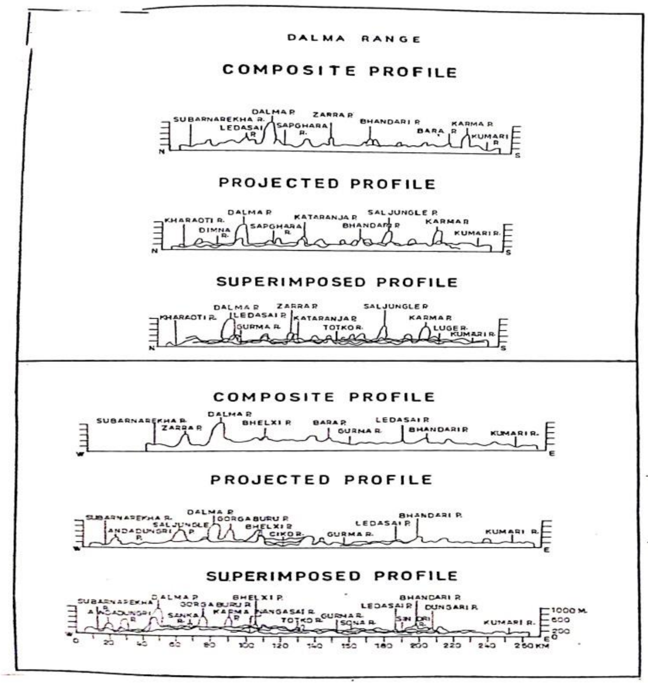

Fig. 7

The Lower Subarnarekha Surface (100m-125m)

The lower Subarnarekha surface is developed on the Archaean granites and gneisses including charnockites and small pockets of Gondwana rocks in the southeastern part of the study area. It forms a narrow elongated belt of faint relief with elevations of 100m-125m on both the flanks of the Subarnarekha river. A few residual hills, namely Mahulia (175m), Khengar (Him) peneplains, Chadri (440m) and Chakotia (275m) pahars stand above this surface.

Summary and Conclusion-

The elevation, in the area, ranges from below 150m to over 900m and the altitudinal zones are less than 150m, 150m-300m, 300m-450m, 450m-600m, 600m-750m, 750m-900m and over 900m, which account for 2.30%, 57.15%, 26.43%, 9.95%, 3.06%. 0.76% and 0.35% of the study area respectively. The mean, median and model values of elevation are 318.0m, 274.8m and 246.1m respectively. The hypsometric curve shows occurrence of gently undulating peneplains at the elevation of 400m-450m and 600m-750m, the altimetric frequency diagram also shows occurrence of

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maximum frequencies in the height category of 150m-300m with a second maximum at 300m-450m. The areal distribution of relative relief categories shows that less than 15m (Rel), 15m-30m (Rl), 30m-60m (Rml), 60m-120m (Rm), 120m-240m (Rmh), 240m-450m (Rh) and over 480m (Rvh) account for 13.82%, 17.62%, 9.96%, 19.56%,., 15.33% and 2.38% of the study area respectively. Low relative relief (0-60m) characterizes 41.34% of the study area, it is typical of the low-lying riverine plains of the Subarnarekha valley in the northwest and Kumari valley in northeast and most of the gently undulating penelained surfaces of upper and lower Dalma range. Moderate relative relief (60m-120m) account for 24.85% of the range surface. It is found in the moderately dissected part of the peneplain near Penchara (268m), Kumari (262m) peneplains and Guma valley (300m), etc. High relative relief (over 240m) is noted about 15.33% of the area, mostly confined to the Teliya. The mean, median and model values of the relative relief are 132.41m, 69.16m and 48.94m respectively. These lies in the categories of low and moderate relative relief respectively. A high degree of positive correlation (r =+0.78) is obtained between relative relief and absolute relief in the study area.

The Dissection index categories of less than 0.1 (Dl), 0.1-0.2 (Dm), 0.2-0.3 (Dmh), 0.3-0.4 (Dh) and over 0.4 (Dvh) account for 8.81%, 21.07%, 15.33%, 14.56% and 140.23% of the study area respectively. Low dissection index is typical of the lower catchments of the Subarnarekha and Kumari rivers in the southeast and the less dissected part of upper Dalama range. Moderate dissection index (0.1-0.3) is generally associated with the deeply dissected flanks of the residual hills like Amda(409m), Urma (441m), pahars. Generally high dissection index (over 0.3) coincides with the highly dissected hill-complex, like Chadari (440m), Dalma (1000m), Bhelxi (780m), and Chekam (57m) pahars and the steeply sloping margins of the upland. The mean, median and modal values of dissection index are 0.20, 0.33 and 0.43 respectively. These indicate that the present topography is in the 'old stage' or late mature stage' of dissection. There is a moderate positive correlation (r =+0.65) between dissection index and absolute relief. Analysis of relief, including construction of various types of profiles has revealed the existence of the following erosion surface in the area: (i) 900m-1000m high surface of residual hill-topes on upper Dalma range, (ii) the upper Dalma range surface (600m), (iii) The lower Dalma range surface (300m-350m), (iv) the lower Subarnarekha surface (100m-125m). The relative relief map is used for defining landuse, land classification has a great bearing upon varying types of terrain. It is therefore, suggested that choromorphographic map can be drawn to utilize it for land classification and landuse maps. Superimposed and projected profiles brilliantly express the different surfaces of the region. The geomorphlogical history of an area distinctly defines and helps in the classification of different types of landforms which form the stage for an enactment of cultural landscape. Its application can be extended to every sphere of human geography.

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